

CONVEYING DEVICE WITH PERISTALTIC MOVEMENT

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to conveying devices with peristaltic movement, and it particularly relates to a technology by which to convey and carry an object with peristaltic movement.

10 Description of the Related Art

As methods for conveying the liquid, slurry-like objects or solid objects, there are available a screw-type method, a method utilizing the air pressure generated by piston actions and rotary pumps, and so forth. As for the path through which 15 the objects are conveyed, the screw-type method can be applied to a rod-shape object whereas the piston actions, rotary pumps can be applied to curved or flexible regions. However, if the screw-type method or the method utilizing the air pressure generated by piston actions and rotary pumps are to be used, 20 an additional space needs to be secured for installing a power source such as a motor or pump.

Relate Art List

(1) Japanese Patent Application Laid-Open No. 2002-20848.

Here, the screw-type method can be applied to objects

having the rigid shape only, so that it cannot be applied to the curved or flexible regions such as artificial esophagus. Besides, this screw-type method will be of no use unless there is secured a space for setting up the power source such as a 5 motor.

If the object is conveyed in a structure such that the air pressure generated by the piston actions or the rotary pump is press-fit into the rubber hose, the piston or rotary pump may be installed in the curved or flexible region.

10 However, if it is hard to secure the space for installing the power source such as a pump, this structure is also of no use then.

The esophagus' operation is one of the most difficult operations in the surgery since the esophagus needs to be 15 reconstructed after the removal of esophageal cancer. The stomach or the enteric canal is involved in the reconstruction of the esophagus, thus requiring an abdominal incision. As a result, the surgical stress and the risk accompanied thereby are high. The provision of the proper artificial esophagus, 20 should it ever be made, therefore simplifies the operation significantly. The development of the artificial esophagus is far behind compared with the other artificial internal organs. The conventional artificial esophagus is a mere tube made of polymeric material, and cannot perform the peristaltic

movement. Even if the cell renewal of esophagi is possible with the help of the regenerative medicines, the peristaltic movement cannot be realized due to the lack of tunica muscularis ventriculi.

5 Even with the artificial esophagus using mechanical screws, a structure thereof is such that the screw sticks out of the mouth. This is rather out of the question and is totally unrealistic and not usable in the actual setting. Moreover, even if achieving the peristaltic movement is
10 intended by use of a motor, it is obvious that there is no such spare space to place the motor in the esophagus. Thus this scheme is unrealistic, too, and must be abandoned.

Accordingly, there has not been available any artificial esophagus like the human esophagus which can be actually
15 embedded inside the human body and is capable of achieving the peristaltic movement.

SUMMARY OF THE INVENTION

The present invention has been made in view of the
20 foregoing circumstances and an object thereof is to provide a conveying device, including a transport tube that can be installed in a region having a rigid, curved or flexible shape, which does not require a space for installing a power supply source.

In order to solve the above problems, a conveying device with peristaltic movement according to a preferred embodiment of the present invention includes a flexible transport tube. A cross-sectional area of transport path in the flexible 5 transport tube is contracted by utilizing contractive force obtained when a two-way shape memory alloy is heated, and an original cross-sectional area of transport path in the flexible transport tube is restored by utilizing recovery force obtained when heating the two-way shape memory alloy is 10 terminated. Then, the conveying device with peristaltic movement conveys an object in a predetermined direction by a temperature controlling device that controls repetition of the contraction motion and the restoration motion.

This conveying device with peristaltic movement may 15 further include a two-way shape memory alloy and a temperature controlling device. The contraction motion or the restoration motion may be an action that causes part of the cross-sectional area of transport path in the flexible transport tube to be contracted or restored. The temperature 20 controlling device may move sequentially a position to be contracted or to be restored in an object conveying direction. The two-way shape memory alloy may be of a fine wire shape or a coil form. The two-way shape memory alloy may be a plate form or a ring form.

The temperature controlling device may be an electric conduction and heating device which changes the temperature of the two-way shape memory alloy. The temperature controlling device may be an external heating device which changes the 5 temperature of the two-way shape memory alloy.

The present invention may adopt any of the following preferred embodiments.

According to a preferred embodiment of the present invention, there is provided a flexible transport tube which 10 can be installed or mounted at any arbitrary positions. A cross-sectional area of transport path in the flexible transport tube is contracted by utilizing a property that a two-way shape memory alloy contracts by electrically conducting and heating the two-way shape memory alloy. Then, 15 by terminating the electrical conduction of the two-way shape memory alloy, the two-way shape memory alloy is restored to a substantially original length thereof so as to return the cross-sectional area of transport path in the transport tube to a substantially original cross-sectional area thereof. An 20 object inside the transport tube is conveyed in a certain direction while the repetition of contraction motion and restoration motion is controlled by a temperature controlling device.

According to another preferred embodiment of the present

invention, there is provided a conveying device with peristaltic movement wherein a transport tube is of a cylindrical shape. This conveying device with peristaltic movement further includes a two-way shape memory alloy and a 5 temperature controlling device.

According to still another preferred embodiment of the present invention, there is provided a conveying device with peristaltic movement wherein a two-way shape memory alloy is mounted inside or on the surface of a transport tube by which 10 the peristaltic movement is realized. Here, the two-way shape memory alloy is the shape memory alloy, described in Japanese Patent Application Laid-Open No. 2002-20848, which overcomes the drawback of the general shape memory alloy and has the enormous two-way shape memory effect. The action by which the 15 cross-sectional area of transport path in the transport tube is contracted or restored is the motion realized by contracting and restoring part of the cross-sectional area of transport path in the transport tube. The temperature controlling device moves sequentially a position at which the 20 action of contraction or restoration is effected, in an object conveying direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a side view of a conveying device, with peristaltic movement, utilizing two-way shape memory alloy.

FIG. 1B is a cross-sectional view of the conveying device with peristaltic movement taken along the line A-A of FIG. 1A.

FIG. 2A is a side view of a conveying device with peristaltic movement utilizing two-way shape memory alloy when the two-way shape memory alloy is arranged in a ring form.

FIG. 2B is a cross-sectional view of the conveying device with peristaltic movement taken along the line A-A of FIG. 2A.

FIG. 3A is a side view of a conveying device with peristaltic movement utilizing two-way shape memory alloy and an external heating device when the two-way shape memory alloy is arranged in a ring form.

FIG. 3B is a cross-sectional view of the conveying device with peristaltic movement taken along the line A-A of FIG. 3A.

FIG. 4A is a side view of a conveying device with peristaltic movement utilizing two-way shape memory alloy when the two-way shape memory alloy is arranged in a ring form inside a transport tube.

FIG. 4B is a cross-sectional view of the conveying

device with peristaltic movement taken along the line A-A of FIG. 4A.

FIG. 5 is a diagram showing a control circuit of a conveying device with peristaltic movement utilizing two-way 5 shape memory alloy.

FIG. 6 is a diagram showing a control circuit of a conveying device with peristaltic movement utilizing two-way shape memory alloy and an external heating device.

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DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described based on the following embodiments which do not intend to limit the scope of the present invention but exemplify the invention. All of the features and the combinations thereof described in the 15 embodiments are not necessarily essential to the invention.

A conveying device with peristaltic movement contracts and restores a part of cross-sectional area of transport path in a transport tube which is flexible or of sufficiently flexing nature, by exerting actions of expansion and 20 contraction on two-way shape memory alloy. The transport tube may be made of rubber, collagen, polyurethane, polyester and so forth. This conveying device with peristaltic movement conveys an object by contracting and restoring the cross-sectional area of transport path at a position while the

position is being changed sequentially in a direction that the object is to be transported. This action is called "peristaltic movement."

The two-way shape memory alloy is arranged on the 5 surface or inside the transport tube in a helical or ring form or in a combined form thereof. Changing a cross-sectional area of transport path in the transport tube is realized by varying the temperature of the two-way shape memory alloy and thus by expanding and contracting the two-way shape memory 10 alloy.

As a method of changing the temperature of the two-way shape memory alloy, the heat may be self-generated by electrically conducting the two-way shape memory alloy, or a method in which an element, such as a Peltier element, having 15 heating and cooling characteristics is mounted on the two-way shape memory alloy or a method combining these may be used.

The technology according to the present embodiment can be applied to the medical field, and this conveying device with peristaltic movement may be used as artificial esophagus.

20 When used as artificial esophagus, a state of the peristaltic movement therefor is such that the inner diameter of the transport tube changes preferably in the range from approximately 1mm at the time of contraction to approximately 50mm at the time of expansion and the moving rate thereof

ranges preferably from approximately 1mm/sec minimum to approximately 100mm/sec maximum.

As conditions under which this peristaltic movement can be realized, it is required to generate the percentage of contraction at approximately 2% to 200% and the contractive force of approximately 10g or greater. In order to meet this condition, the two-way shape memory alloy is formed into a coil form or the like by which the high percentage of contraction and the high contractive force are generated, so that the above-mentioned percentage of contraction and the contractive force are realized.

The conveying device with peristaltic movement may further be applied to and used to convey various industrial liquids, slurry-like objects and the like.

The present embodiments will be described in detail referring to drawings. FIG. 1A and FIG. 1B illustrate a fundamental structure of a conveying device with peristaltic movement. FIG. 1A is a side view of a conveying device with peristaltic movement according to a first embodiment. The conveying device with peristaltic movement includes a transport tube 1, a plurality of two-way shape memory alloys 2 and a plurality of wirings 3. The plurality of two-way shape memory alloys 2 are provided around the periphery of the transport tube 1 in such a manner that they are separately

wound around the periphery of the transport tube 1 at a plurality of respective positions. The two-way shape memory alloys 2 wound around the transport tube 1 at the plurality of respective positions are disposed in parallel to one another.

5 The plurality of two-way shape memory alloys 2 are provided respectively with the plurality of wirings 3, and the two-way shape memory alloys 2 can be electrically conducted and heated thereby separately. FIG. 1B is a cross-sectional view of the conveying device with peristaltic movement taken along the

10 line A-A of FIG. 1A according to the first embodiment. The two-way shape memory alloy 2 is provided, in the form of a ring, around the periphery of the transport tube which can be installed in a region having a rigid-and-rod-like, curved or flexible shape. The wiring 3 is connected to the ends of the

15 two-way shape memory alloy 2 so as to electrically conduct and heat the two-way shape memory alloy 2 and control the heating thereof.

FIG. 2A is a side view of a conveying device with peristaltic movement according to a second embodiment. FIG. 2B is a cross-sectional view of the conveying device with peristaltic movement taken along the line A-A of FIG. 2A according to the second embodiment. A plurality of two-way shape memory alloys 2 are respectively provided, in helical fashion, around the periphery of the transport tube 1 which

can be installed in a region having a rigid-and-rod-like, curved or flexible shape. The plurality of two-way shape memory alloys 2 are provided in such a manner that each of the plurality of two-way shape memory alloys 2 is separately wound 5 around the transport tube 1 a few or several number of times. The wirings 3 are respectively connected to the ends of the two-way shape memory alloys 2 so as to electrically conduct and heat the two-way shape memory alloys 2 and control the heating thereof. The plurality of two-way shape memory alloys 10 2 can be electrically conducted and heated separately and independently among them.

FIG. 3A is a side view of a conveying device with peristaltic according to a third embodiment. FIG. 3B is a cross-sectional view of the conveying device with peristaltic 15 movement taken along the line A-A of FIG. 3A according to the third embodiment. At a plurality of respective positions, a plurality of two-way shape memory alloys 2 and a plurality of external heating devices are provided, in the form of a ring, externally to the transport tube 1 which can be installed in a 20 region having a rigid-and-rod-like, curved or flexible shape. The wirings 3 are respectively connected to the ends of the two-way shape memory alloys 2 so as to control the heating of the two-way shape memory alloys 2. The plurality of two-way shape memory alloys 2 and the plurality of external heating

devices 4 can be electrically conducted and heated separately and independently at the plurality of positions.

FIG. 4A is a side view of a conveying device with peristaltic movement according to a fourth embodiment. FIG. 5 4B is a cross-sectional view of the conveying device with peristaltic movement taken along the line A-A of FIG. 4A according to the fourth embodiment. At a plurality of respective positions, a plurality of two-way shape memory alloys 2 are provided, in the form of a ring, inside the transport tube 1 which can be installed in a region having a rigid-and-rod-like, curved or flexible shape. The wirings 3 are respectively connected to the ends of the two-way shape memory alloys 2 so as to control the heating of the two-way shape memory alloys 2. The plurality of two-way shape memory alloys 2 are provided in such a manner that each of the plurality of two-way shape memory alloys 2 is separately wound around inside the transport tube 1 a few or several number of times and can be electrically conducted and heated separately and independently at the plurality of positions.

20 FIG. 5 shows a control circuit for controlling a conveying device with peristaltic movement according to the first, second and fourth embodiments. This control circuit controls a plurality of switches 5 and electrically conducts the plurality of two-way shape memory alloys 2 sequentially in

a fixed direction. The two-way shape memory alloys 2 are thereby expanded and contracted so as to produce peristaltic movements.

FIG. 6 shows a control circuit for controlling a 5 conveying device with peristaltic movement according to the third embodiment. This control circuit controls a plurality of switches 5 and electrically conducts the plurality of external heating devices 4 sequentially in a fixed direction. The two-way shape memory alloys 2 are thereby expanded and 10 contracted so as to produce peristaltic movements.

As have been described above, the conveying device with peristaltic movement according to the present embodiments can be installed not only in a rigid- or rod-like region but also in a curved or flexible region, and it does require the space 15 for setting up a power source therefor. Thus, the conveying device with peristaltic movement according to the present embodiments can be utilized also as artificial esophagus that meets preconditions such as those described as above.

Accordingly, if used as artificial esophagus, the 20 conveying device with peristaltic movement according to the present embodiments can be applied to and used as patient's esophagus after the removal of esophageal cancer. Moreover, the conveying device with peristaltic movement according to the present embodiments can be adapted to artificial esophagus

for elderly persons whose respiratory functions are deteriorated.

Although the present invention has been described by way of exemplary embodiments, it should be understood that many 5 changes and substitutions may further be made by those skilled in the art without departing from the scope of the present invention which is defined by the appended claims.